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Predictive value of Point-of-Care Ultrasound for difficult spinal anaesthesia in obstetric patients

Kavitha Dharavath[1], Chandavathu Padma[2], Godipelli Laxmi[3]
[1, 2, 3]Assistant Professor, department of Obstetrics and Gynaecology, Kakatiya Medical College and Government Maternity Hospital, Hanamkonda.

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Corresponding Author: Dr Godipelli Laxmi
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Abstract

Background: Difficult spinal anaesthesia is common in obstetric patients due to altered lumbar anatomy and poor surface landmarks. Point-of-care ultrasound (POCUS) has emerged as an important tool for identifying anatomical challenges before needle insertion. **Aim:** To evaluate the usefulness of POCUS in predicting difficult spinal anaesthesia among obstetric patients undergoing caesarean delivery.

Methods: This prospective study was conducted from January to May 2025 in the Department of Obstetrics and Gynaecology, Kakatiya Medical College, Warangal. Pre-procedural lumbar POCUS was performed to measure skin-to-dura depth, interspinous gap width, and landmark clarity. Spinal anaesthesia was administered by blinded anaesthesiologists, and difficulty was assessed based on number of attempts, redirections, and procedural time. Data were analysed using appropriate statistical tests.

Results: Among 120 patients, 36.7% were predicted to have a difficult spinal. Difficult POCUS findings were strongly associated with ≥3 attempts, increased redirections, and procedural time >150 seconds ($p < 0.001$). Poor landmark visibility and greater skin-to-dura depth were significant predictors of difficulty.

Conclusion: POCUS is a reliable tool for predicting difficult spinal anaesthesia in obstetric patients. Its routine use may improve procedural success, enhance safety, and reduce complications.

Keywords: POCUS, Obstetric anaesthesia, Spinal, Ultrasound guidance, Neuraxial block

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Introduction

Point-of-care ultrasound (POCUS) has emerged as an important adjunct for obstetric anaesthesiologists, allowing real-time visualization of lumbar anatomy, estimation of skin-to-epidural/intrathecal depth, and identification of midline in parturients with challenging surface landmarks [1,2]. Recent studies demonstrate that neuraxial ultrasound improves first-attempt success, reduces needle passes, and helps identify patients in whom spinal insertion is likely to be difficult [3,4]. Predicting a difficult spinal anaesthetic is particularly relevant in obstetric patients, who often have obesity, oedema, and accentuated lumbar lordosis, all of which increase technical difficulty and procedure time [1, 2]. The present study aims to evaluate the usefulness of lumbar POCUS in predicting difficult spinal anaesthesia (SA) in obstetric patients, by correlating pre-procedural ultrasound findings with procedural outcomes such as number of attempts, needle redirections, and failed blocks.

Methods:

This prospective observational study was conducted in the department of Obstetrics and Gynaecology at Kakatiya Medical College, Warangal, from January to May 2025. All obstetric patients scheduled for lower segment caesarean section (LSCS) under SA during the study period were screened for eligibility. Women aged 18–40 years with singleton term pregnancies and classified as ASA II–III were included after obtaining informed written consent. Patients with contraindications to SA, such as local infection at the puncture site, coagulopathy, spinal deformities, or previous lumbar spine surgery, were excluded. Baseline demographic parameters, obstetric details, and body mass index (BMI) were recorded. All procedures were performed by anaesthesiologists with a minimum of two years of experience in obstetric anaesthesia to minimise operator variability.

Pre-procedural POCUS was performed in all enrolled patients in the sitting position using a low-frequency curvilinear probe (2–5 MHz). The lumbar spine was scanned in both transverse and longitudinal paramedian planes to identify key anatomical features, including the midline, interspinous spaces, ligamentum flavum–dura mater complex, and estimated depth to the intrathecal space. The L3–L4 or L4–L5 interspace was selected based on optimal ultrasound visibility and measurements were documented, including skin-to-dura depth, interspinous gap width, and quality of anatomical landmark visualisation. Each scan was graded as easy, intermediate, or difficult based on predefined sonographic criteria. The anaesthesiologist performing the spinal block was blinded to the ultrasound grading but was informed of the optimal insertion point according to ultrasound guidance. SA was administered using a

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25G Quincke or 27G pencil-point needle with the patient in the sitting position, following standard aseptic precautions.

Procedural outcomes were recorded in real time. Difficulty of SA was assessed using objective parameters: number of needle insertion attempts, number of redirections, requirement for change of interspace, need for a senior anaesthesiologist's assistance, failed spinal block, and total procedural time from needle insertion to free flow of cerebrospinal fluid (CSF). A difficult SA was defined as ≥3 attempts, ≥5 redirections, or failure to enter the subarachnoid space within 5 minutes. Correlation between pre-procedural ultrasound findings and procedural difficulty was analysed to determine the predictive value of POCUS. Secondary outcomes included maternal discomfort scores during needle insertion, incidence of traumatic tap, and need for conversion to general anaesthesia. Data were compiled using Microsoft Excel and analysed with SPSS version 23.0. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. Associations between ultrasound parameters and procedural difficulty were evaluated using Chi-square test, independent t-test, or logistic regression as appropriate. A p-value <0.05 was considered statistically significant.

Results:

A total of 120 obstetric patients were included in this prospective study, with a mean age of 26.4 years and mean BMI of 29.8 kg/m². Nearly half of the participants were primigravidae. Baseline characteristics were comparable across those predicted to have easy and difficult SA. Pre-procedural ultrasound evaluation demonstrated that 60% of patients had good visibility of lumbar landmarks, whereas 40% had poor visibility. The mean skin-to-dura depth was 4.8 cm, and 36.7% of patients were categorised as having a predicted difficult spinal based on POCUS criteria (Table 1). Regarding procedural performance, the mean number of attempts required for successful dural puncture was 2.1, with an average of 3.9 redirections. The overall mean procedural time was 138 seconds, and the incidence of traumatic tap and block failure were 15% and 5%, respectively (Table 2). A strong and statistically significant association was observed between POCUS-predicted difficulty and actual procedural difficulty. Patients categorised as predicted difficult had markedly higher rates of ≥3 attempts (54.5% vs. 13.1%), prolonged procedure time exceeding 150 seconds (65.9% vs. 18.4%), and difficult SA overall (63.6% vs. 15.8%), all with $p < 0.001$ (Table 3).

Discussion:

The findings of this prospective study reinforce the growing evidence that POCUS offers substantial value in predicting difficult SA in obstetric patients. Anatomical challenges in parturients such as obesity, oedema, exaggerated lumbar lordosis, and poorly palpable surface landmarks—are well-known contributors to difficult neuraxial blocks [5]. In the present study, poor landmark visibility on ultrasound correlated strongly with increased procedural attempts and prolonged duration, supporting prior observations that ultrasound improves identification of optimal interspaces and midline orientation [6]. Recent literature suggests that POCUS not only enhances first-attempt success rates but also reduces patient discomfort by minimising unnecessary needle redirections [7]. The present study's results align with these findings, demonstrating significantly higher success and shorter procedural times when ultrasound predicted an easy spinal insertion. By providing real-time depth estimation and imaging of the ligamentum flavum–dura mater complex, POCUS overcomes the subjective limitations of landmark-based techniques and contributes to objective risk stratification [8].

This study also highlights the predictive capacity of specific sonographic parameters, particularly skin-to-dura depth and interspinous gap width. Previous research shows that a greater soft-tissue depth is strongly associated with multiple needle passes and technical difficulty, especially in obese obstetric patients [9]. Our results are consistent with these associations, as increased skin-to-dura depth correlated with prolonged procedural time and higher likelihood of ≥3 attempts. Furthermore, individuals with narrow interspinous gaps demonstrated greater procedural difficulty, supporting earlier studies that linked reduced anatomical space with compromised needle trajectory and limited manoeuvrability [10]. The significant correlation between POCUS-predicted and actual procedural difficulty in our cohort indicates that pre-procedural ultrasound can function as a valuable anticipatory tool, allowing anaesthesiologists to allocate more experienced operators to anticipated difficult cases. This aligns with growing recommendations that neuraxial ultrasound should be integrated into routine practice, especially in high-risk obstetric populations or during emergency caesarean delivery when efficiency and safety are paramount [11].

In addition to enhancing procedural efficiency, POCUS may contribute to improved patient safety and overall clinical outcomes. Difficult spinal attempts are associated with increased risk of maternal discomfort, traumatic tap, post-dural puncture headache, and inadvertent epidural placement, all of which may complicate obstetric anaesthesia management [12]. In the current study, traumatic taps were more frequent in patients

predicted to be difficult, emphasising the potential of POCUS to mitigate complications through early identification of high-risk anatomy. Although the present study did not assess patient-reported outcomes such as pain or satisfaction scores in detail, previous trials demonstrate that ultrasound guidance enhances overall maternal experience by reducing anxiety related to repeated needle insertions [7]. A further implication of our findings is the potential reduction in the need for conversion to general anaesthesia a significant concern in obstetric populations due to difficult airway rates and higher aspiration risk. Future studies may investigate whether systematic POCUS assessment reduces conversion rates and improves perioperative safety metrics. Overall, the results of this study support the integration of POCUS into pre-procedural SA evaluation to enhance predictability, reduce complications, and improve success rates in obstetric settings. Larger multicentric studies may refine ultrasound-based prediction models and help establish standardised POCUS protocols tailored for diverse obstetric populations.

Conclusion: The present study demonstrated that POCUS is a valuable and reliable tool for predicting difficult SA in obstetric patients. Sonographic parameters such as skin-to-dura depth, interspinous gap width, and landmark visibility showed strong correlation with increased procedural attempts, redirections, and prolonged procedural time. POCUS effectively identified patients at higher risk for technical difficulty, allowing better preparation, operator selection, and optimisation of patient care. Integrating routine pre-procedural ultrasound assessment into obstetric anaesthesia practice can enhance safety, improve success rates, and reduce complications. Further large-scale studies may refine prediction models and standardise POCUS-guided neuraxial protocols.

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Table 1: POCUS based ultrasonographic parameters among the study members	
Parameter	**Mean ± SD / n (%)**
Skin-to-dura depth (cm)	4.8 ± 0.7
Interspinous gap width (mm)	11.3 ± 2.6
Spine landmark visibility—Good	72 (60)
Spine landmark visibility—Poor	48 (40)
Difficulty category (POCUS) – Predicted difficult	44 (36.7)

Table 2: Procedural characteristics of SA among the study members	
Variable	**Mean ± SD / n (%)**
Number of attempts	2.1 ± 1.2
Number of needle redirections	3.9 ± 2.4
Procedural time (seconds)	138 ± 42
Traumatic tap	18 (15)
Failure of spinal block	6 (5)

Table 3: Association between POCUS difficulty prediction and actual procedural difficulty among the study members			
Variable	**Predicted Easy (n=76)**	**Predicted Difficult (n=44)**	**p-value**
Difficult SA	12 (15.8%)	28 (63.6%)	<0.001*
≥3 attempts	10 (13.1%)	24 (54.5%)	<0.001*
Procedural time >150 s	14 (18.4%)	29 (65.9%)	<0.001*